KEEPING RECEIVING WATERS SAFE: REMOVING POLY- & PERFLUOROALKYL SUBSTANCES (PFAS)

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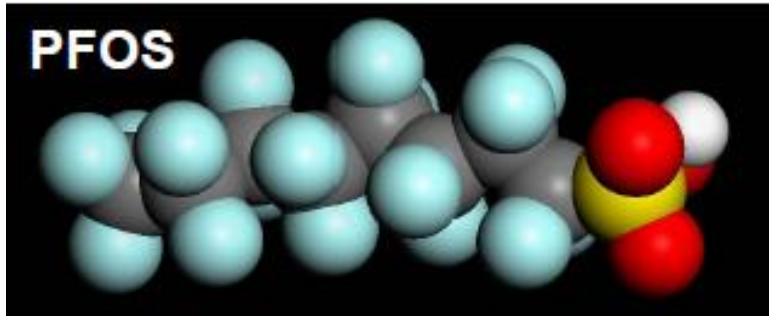
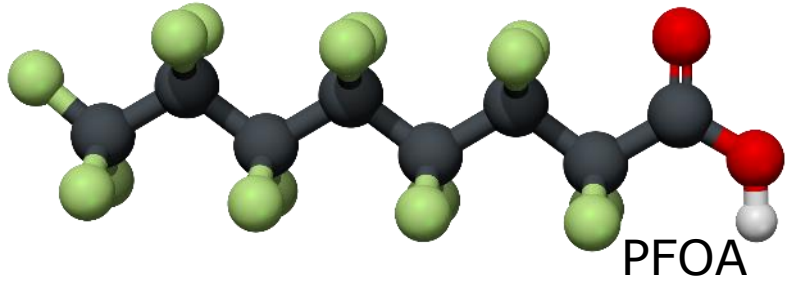
PFAS– AT A GLANCE

- Human-made substances
- Do not hydrolyze, photolyze or biodegrade under typical environmental conditions and are extremely persistent in the environment
  - C-F bond is one of the strongest bonds
- Found in soil, air and groundwater at sites around the world
- Toxicity, mobility and bioaccumulation potential pose potential adverse effects for the environment and human health
- Regulatory authorities have developed health-based advisories or screening levels

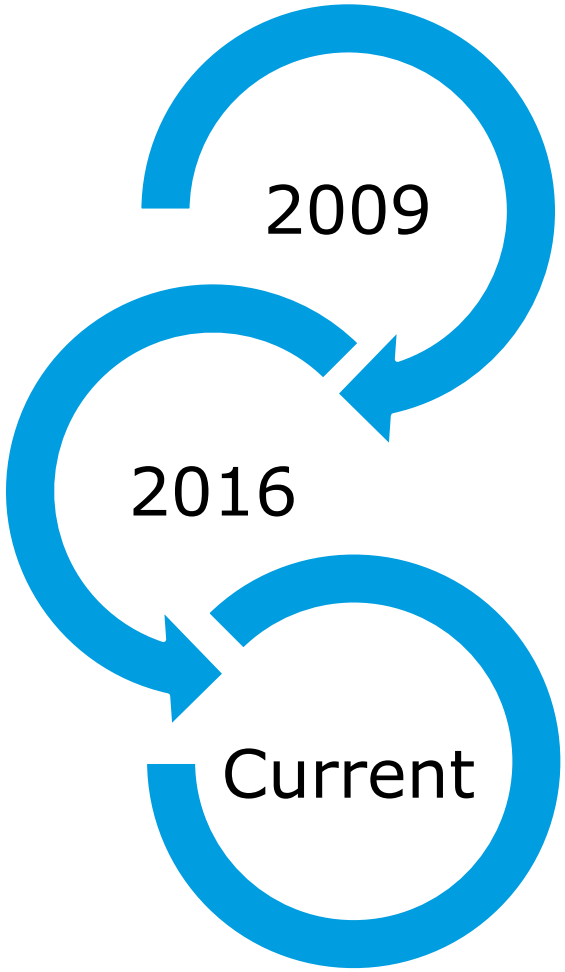




- PFOS and PFOA have been detected globally in the tissues of fish, bird and marine mammals.

CONTROLLING PFAS

USEPA issues lifetime Health Advisory
- PFOS = 70 ng/L
- PFOA = 70 ng/L



USEPA issues Provisional Health Advisory
- PFOS = 200 ng/L
- PFOA = 400 ng/L.

Continuous regulatory changing climate
- Where are we going?

HISTORICAL COMMERCIAL USES OF PFOS/PFOA

- Fabric coatings
- Carpet coatings
- Paper coatings
- Floor polish
- Alkaline cleaners
- Denture cleaners
- Shampoos
- Insecticides

- Aqueous film forming foam AFFF (fire-fighting agents)
- Aviation hydraulic fluid
- Mining/oil well surfactant
- Acid rust suppressant
- Metal plating
- Electronic etching bath

POTENTIAL TREATMENT TECHNOLOGIES

Treatment Technology	Description
Granular Activated Carbon (GAC)	• Good PFAS removal efficiency 80 – 99% can be achieved • The isotherms are very steep at low concentrations: there are a limited number of adsorption sites with very favorable adsorption energies resulting in high doses • Two stage systems typically required • Three stage in some wastewaters • Slightly better capacity at lower pH values • Requires reactivation at very high temperatures or disposal of spent carbon
Polymeric Resin Adsorption	• PFC removals can be as high as 95% • Long contact times typically required • Requires resin regeneration and regenerant treatment
Membrane Filtration	• RO can remove nearly all PFCs - up to 99% PFOS removal • UF can achieve 70-80% removal • NF can achieve 85-90% removal • Produces a concentrate that requires additional treatment

Advanced Oxidation (AO)	• Can remove all PFAS compounds in wastestreams depending upon technology
	  • Supercritical Water Oxidation
	  • Incineration
	• Requires high energy

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GENERATOR WASTEWATER TREATMENT EXAMPLE

- One of the first US comprehensive treatment evaluations conducted
- Limited public data
  - Industry proprietary property
- Challenging analytical
- Aggressive environment

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GENERATOR WASTEWATER TREATMENT EXAMPLE

- Treatability included:

Bench-scale

- Membrane technologies
- Granular Activated Carbon
- Foam fractionation
- Solvent extraction
- Supercritical oxidation
- Ion exchange
- Freeze crystallization
- Evaporation
- Supercritical CO_2 Extraction
- XAD resins
- C-18 resins
- Alum coagulation
- Organo clays
- Spun glass fiber
- Mycell absorption
- Glass beds & powder
- Zeolite

Pilot-scale

- Granular Activated Carbon
- Supercritical Water Oxidation
- Foam fractionation
- Freeze crystallization

GENERATOR WASTEWATER TREATMENT EXAMPLE

- One of the largest industrial GAC treatment systems in the US
  - 26 vessels containing 20,000 lbs each of installed GAC
  - Capacity to treat a combined flow of over 3 mgd
  - Provided effective treatment of below regulated levels
- Facility has since expanded treatment capacity

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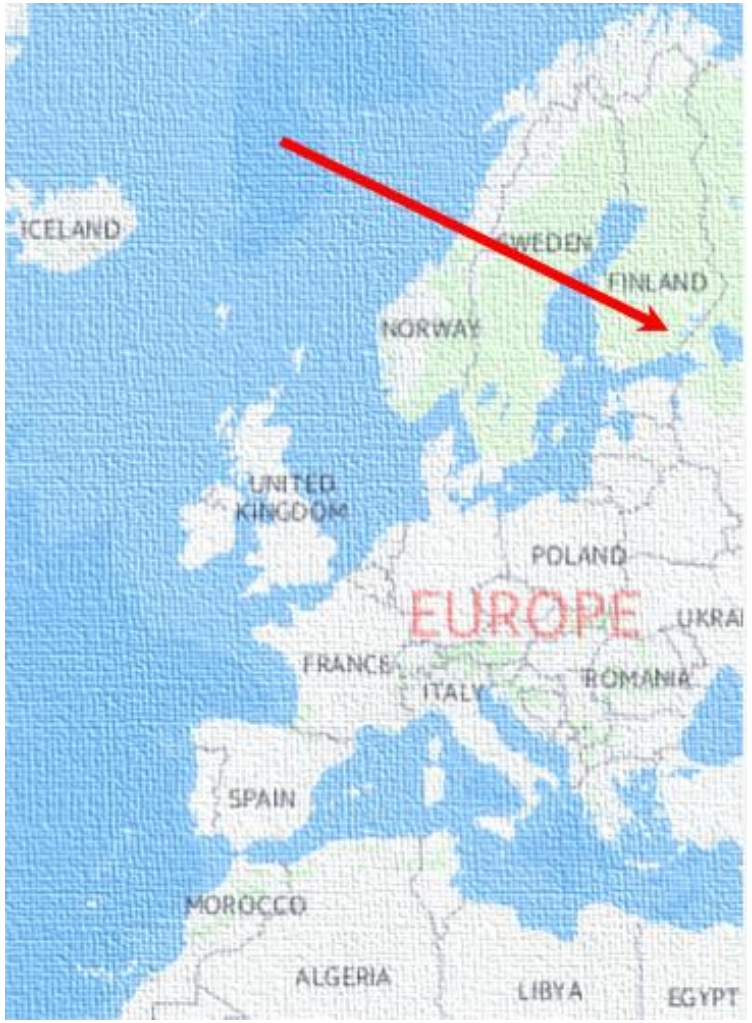
MUNICIPAL WASTEWATER TREATMENT EXAMPLE

- New underground treatment plant in Mikkeli Finland
- Selected primary treatment technology: Membrane Bioreactor Reactor
- More stringent requirements coming in EU for micro pollutants
- Main concern in Mikkeli: PFOS
  - PFOS <0.00065 µg/l
- Advanced tertiary treatment required



MUNICIPAL WASTEWATER TREATMENT EXAMPLE

- Based on pilot testing results, MBR process didn't remove PFOS
- Developed economical[1] and technical assessment of the following potential technologies:
  - Ozonation
  - Reverse Osmosis (RO)
  - Granular Activated Carbon (GAC) Adsorption
  - Advanced Oxidation Process (AOP)
- Adsorption and filtration were found efficient for PFOS removal
- GAC and RO were selected as most cost-effective for this case

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[1] Class 4 Cost estimate as defined by the Association for the Advancement of Cost Engineering (AACE), International Recommended Practices 17R-97 & 18R-97

THANK YOU

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